SPT vs BUS

BUS – Build-up Survey

Conventional single-well testing is based on long-term monitoring of downhole pressure response to the step change in flow rate (usually shut-in or close-in).

The primary hard data deliverables are:

- formation pressure P_i
- skin-factor S
- average transmissibility in drainage area σ
- time to reach the reservoir boundary t_e

The conditional deliverables from build-up survey would be:

Deliverables	Description	Non-BUS Input Parameters	Key Uncertainties
(1) $V_o = \frac{4\,\sigma\,t_e\,(1-s_{wi})}{c_t}$ where c_t is total compressibility: (2) $c_t = c_r + (1-s_{wi})\,c_o + s_{wi}\,c_w$ and $\{c_r,\, c_o\, c_w\}$ are rock, oil and water compressibility.	Drainable oil reserves	The rock compressibility $c_r(\phi)$ is defined from core lab study or empirical porosity correlations Fluid compressibility $\{c_o,\, c_w\}$ from PVT Initial water saturation s_{wi} from SCAL	Rock compressibility $c_r(\phi)$ Initial water saturation s_{wi}

SPT – Self-Pulse Testing

The single-well self-pulse test is based on long-term monitoring of downhole pressure response to the periodic rate step change (usually shut-in or close-in).

If flowrate

The primary hard data deliverables are:

- formation pressure P_i
- skin-factor S
- near σ_{near} and far σ_{far} zone transmissibility
- near χ_{near} and far χ_{far} zone pressure diffusivity
- time to reach the reservoir boundary t_e

The SPT is correlating pressure variation with pre-designed flowrate variation sequence and tracks:

- pressure response amplitude which depends on formation transmissibility σ

and

- time lag between flowrate variation and pressure response which depends on formation diffusivity χ.

This allows estimating effective formation thickness h directly from field survey without assumptions on core-based permeability (compare with (6)) and consequently leads to assessing the drainange area A_e, fluid mobility $\left\langle \frac{k}{\mu} \right\rangle$ and absolute permeability k_a with lesser uncertainties than in BUS:

Deliverables	Description	Non-BUS Input Parameters	Key Uncert

(3) $A_e = 4\,\chi\,t_e$ where χ is pressure diffusivity: (4) $\chi = \left\langle \frac{k}{\mu} \right\rangle \frac{1}{\phi\,c_t}$ where ϕ is reservoir porosity, $\left\langle \frac{k}{\mu} \right\rangle$ is fluid mobility: (5) $\left\langle \frac{k}{\mu} \right\rangle = k_a \left[\frac{k_{rw}}{\mu_w} + \frac{k_{ro}}{\mu_o} \right]$ k_a is absolute permeability to air, $k_{rw},\,k_{ro}$ are relative permeabilities to water and oil, μ_w,μ_o are water and oil viscosities	Drainage area	Formation porosity ϕ Absolute permeability to air k_a from core study Relative permeabilities $\{k_{rw},\,k_{ro}\}$ from SCAL Fluid viscosities $\{\mu_w,\mu_o\}$ from PVT	Absolute permeability to air k_a Relative permeabilities $\{k_{rw},\,k_{ro}\}$
(6) $h = \sigma \left\langle \frac{k}{\mu} \right\rangle^{-1}$	Effective reservoir thickness	Absolute permeability to air k_a from core study Relative permeabilities $\{k_{rw},\,k_{ro}\}$ from SCAL Fluid viscosities $\{\mu_w,\mu_o\}$ from PVT	Absolute permeability to air k_a Relative permeabilities $\{k_{rw},\,k_{ro}\}$

(7)	$h = \frac{\sigma}{\phi\,c_t\,\chi}$	Effective reservoir thickness	Formation porosity ϕ Rock compressibility $c_r(\phi)$ Initial water saturation s_{wi} Fluid compressibility $\{c_o,\,c_w\}$	Rock compres $c_r(\phi)$
(8)	$A_e = \frac{4\,\sigma\,t_e}{c_t\,h}$	Drainage area	Rock compressibility $c_r(\phi)$ Initial water saturation s_{wi} Fluid compressibility $\{c_o,\,c_w\}$	Rock compres $c_r(\phi)$
(9)	$\left\langle \frac{k}{\mu} \right\rangle = \chi\,\phi\,c_t$	Fluid mobility	Rock compressibility $c_r(\phi)$ Initial water saturation s_{wi} Fluid compressibility $\{c_o,\,c_w\}$	Rock compres $c_r(\phi)$ Initial wa saturatic

As one can see, the drainage area and the reservoir thickness are conditioned by core data which may not be representative of the whole drainage area.

(10) $k_a = \frac{\left\langle \frac{k}{\mu} \right\rangle}{\left[\frac{k_{rw}}{\mu_w} + \frac{k_{ro}}{\mu_o} \right]}$	Absolute permeability	Rock compressibility $c_r(\phi)$ Initial water saturation s_{wi} Relative permeabilities $\{k_{rw}, k_{ro}\}$ Fluid viscosities $\{\mu_w, \mu_o\}$ Fluid compressibility $\{c_o, c_w\}$	Rock compres $c_r(\phi)$ Initial wa saturatio Relative permeal $\{k_{rw}, k_{ro}$

The absoluite permeability from SPT $k_a|_{SPT}$ is usually stacked up against core-based permeability $k_a|_{CORE}$ to validate the core samples and assess the effects of macroscopic features which are overlooked at core-plug size level.

Running SPT in two different cycling frequences allows assessing the near and far resevroir zones spearately.

The usual SPT workflow includes several cycling tests with different frequencies, the lower the frequency the longer the scanning range.

This captures variation of permeability and thickness when moving away from well location.

Together with deconvolution, the SPT is reproducing conventional PTA information and providing additional data on pressure diuffusivity.

This maybe used as estimation of permeability and thickness separately and their variation away from well location.